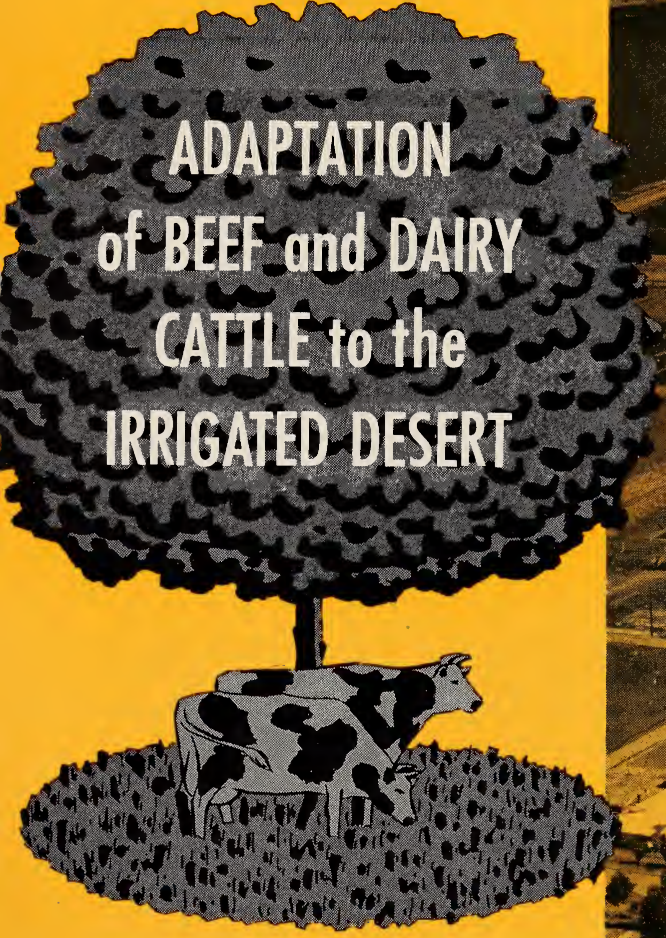
Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

ADAPTATION of BEEF and DAIRY CATTLE to the IRRIGATED DESERT



NICHOLAS R. ITTNER
H. R. GUILBERT
FLOYD D. CARROLL

CALIFORNIA AGRICULTURAL EXPERIMENT STATION

BULLETIN 745

IMPERIAL VALLEY and other irrigated desert areas of California are ideal for cattlemen and dairymen to use in pasture and feedlot operations—except for the summer heat load problem. The heat makes cattle breathe hard. Their body temperatures go up. Milk production goes down, and livestock feed consumption decreases.

TO FIND OUT how gains of beef cattle and production of dairy cows can be improved through reducing the summer heat load, the University of California set up a study program at Imperial Valley Field Station, El Centro. This bulletin tells the results of that study.

PROPER MANAGEMENT, the right feeds, well-constructed shades, cool water, airy corrals, and an understanding of how different breeds react to heat—these are some of the ways described in this bulletin for maintaining beef and dairy cattle production in irrigated desert areas.

THE AUTHORS:

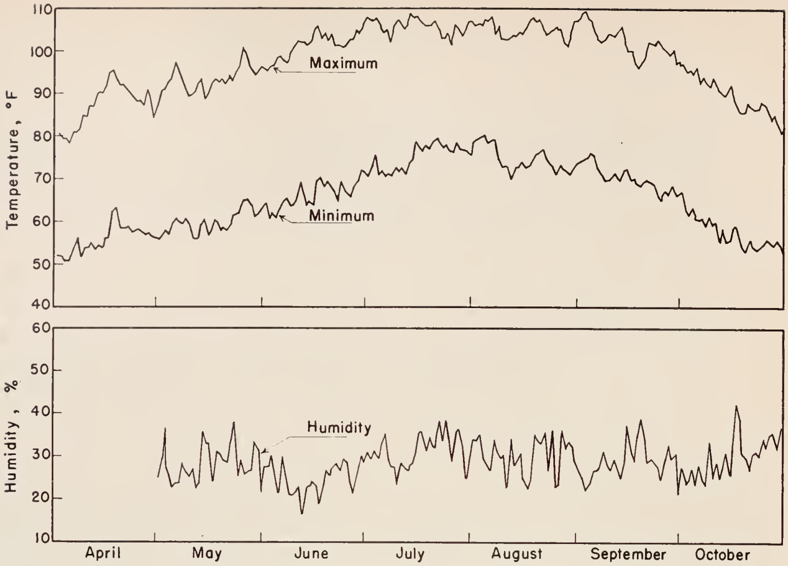
Nicholas R. Ittner is Specialist in the Experiment Station, Imperial Valley Field Station. H. R. Guilbert, Professor of Animal Husbandry, University of California, Davis (deceased). Floyd D. Carroll is Assistant Professor of Animal Husbandry, Davis.

SEPTEMBER, 1954

CONTENTS

APR. TO NOV.

Average for six years 1946–52

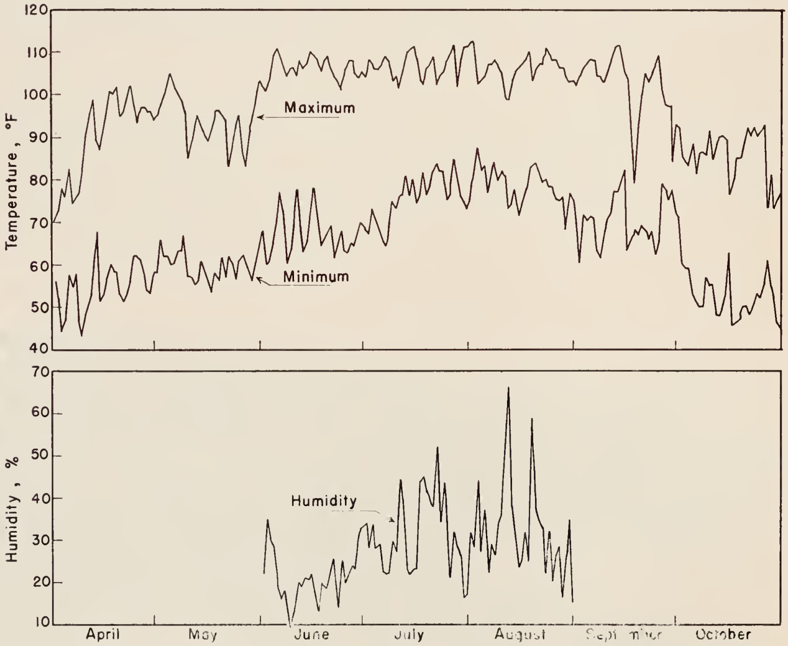


Summers are HOT in the desert area

Figs. 1 and 2 (above and below). Daily maximum and minimum temperatures and noon humidity, April to November, in the desert area of southern California.

APR. TO NOV.

1946



ADAPTATION OF BEEF and DAIRY CATTLE TO the IRRIGATED DESERT

NICHOLAS R. ITTNER · H. R. GUILBERT · FLOYD D. CARROLL

Why, where, and how the studies described here were undertaken

SINCE THE 15TH Century, European cattle have been shipped to many parts of the world. They were accustomed to temperatures averaging 35° Fahrenheit in winter and 65° in summer. In climates similar to Europe's they thrived, but in many others they suffered—for example, in those parts of Africa, Australia, and South, Central and North America where temperatures averaged 75° and higher.

For a long time livestock research aimed at improving the environment to suit the animals. In the last 50 years this trend has changed. The aim now is to develop animals suited to hot climates:* the Africanders of South Africa, the Santa Gertrudis of Texas, the Brahmans, and the Brahmans crossed with European cattle in the South and Southwest.

Imperial Valley—Ideal Except for Summer Heat

Imperial Valley and similar California regions have fed large numbers of cattle and sheep during the winter for many years. Imperial Valley alone fed some 250,000 head of cattle in 1951 and usually feeds 200,000 sheep yearly. Except for high summer temperatures this region is ideal for pasture and feedlot operations because of its long growing season for alfalfa and other pasture crops, because of its abundance of cheap irrigation water, and because of its low average yearly rainfall which eliminates much of the mud problem.†

As more cattlemen began operating in Imperial Valley and other hot California valleys on a year-around basis, the need became apparent for information on summer management of livestock. Early in 1946 the University of California inaugurated a livestock program at Imperial Valley Field Station, El Centro, to study the following: best shades for cattle, livestock gains, food consumption and economy of production in summer; and the comparative values of the different breeds of cattle fed. These studies are still in progress.

The winter research program at the station consists primarily of livestock management studies on pasture and in the feedlot, comparing European and

* A few of the experiment station researchers who have contributed basic information on how livestock react to high temperatures are: J. C. Bonsma, South Africa; J. D. Findlay, Hannah Dairy Research Institute, Scotland; A. O. Rhoad, formerly with the Jeneret Station in Louisiana; W. M. Regan and associates, California Experiment Station, Davis; Samuel Brody and colleagues, University of Missouri; and M. H. Fohrman, U. S. Department of Agriculture.

† Extension Circular 176, *Desert Agriculture*, by N. L. McFarlane and G. L. Winright, gives detailed information on crops and pastures grown in these areas. Manual 2, *California Beef Production*, by H. R. Guilbert and G. H. Hart, has considerable data on the heat tolerance of cattle.

Brahman types of cattle. In addition to this program, the station continuously searches for pasture grasses and legumes that are best adapted to irrigated desert areas.

How Cattle React To Heat, Humidity

Climatic stress in tropical and semitropical regions is caused by air temperature, solar radiation, and humidity—singly or in combination. There is evidence that these factors affect the physiological systems of animals through their anterior pituitary, adrenal, and thyroid glands.

The air temperature beyond which cattle begin to have a higher than normal body temperature is known as the critical temperature; it may be defined as the highest temperature the animal can stand continuously without increase of body temperature. Normal body temperature for the cow is usually considered to be 101° to 102° F.* and the comfort zone for respiration rate is between 20 and 50 per minute.

There is some variation among breeds in the critical temperature. Regan (1) found that for full-fed producing cows the upper critical temperature was about 80° for Holsteins, and 85° for Jerseys; and with each 18° increase in air temperature, respiration rates approximately doubled. Ragsdale et al. (2) found that the critical high temperature at which the depressing effect on milk production, feed consumption, body weight, and a rise in body temperature became evident was 75° to 80° for Holsteins and 80° to 85° for Jerseys. Brahmans are reported by Kibler (3) to have a critical temperature between 90° and 95°.

Reports from South Africa and the United States indicate that Herefords have the highest heat tolerance of the European breeds, followed by the Shorthorn and then the Angus. At 90° Herefords had a respiration rate of 85 per minute, Angus 95 and Shorthorn 141—Bonsma (4). Since European breeds do not sweat, air movement may not be important.

Humidity apparently is not a great factor in the comfort of the dairy cow, except when it approaches saturation. Regan (1), and Seath and Miller (5) believe high humidity is not harmful to dairy cattle. Arrillaga (6) reporting on work done in Puerto Rico, feels that humidity is more of a factor with beef breeds than dairy breeds. The beef breeds he studied were native grades, Brahman grades, and Herefords, while the dairy cattle were Jerseys, Brown Swiss, Guernseys, Ayrshires, and Holsteins. Their adaptability to thermal stress follows that order.

Kibler and Brody (7) report that changes in humidity at temperatures below 75° have little effect on the dairy cattle tested. At higher temperatures changes in humidity raised body temperatures and respiration rates. These relative humidities ranged from 40 to 75 per cent at temperatures ranging between 75° and 100°. California's desert areas usually have humidities below 40 per cent during the heat of the day and more often than not range between 15 and 35 per cent. Humidity is probably not much of a problem in this area except as discussed under climatic conditions.

European cattle lose some water by transpiration through the skin but they do not sweat; this is a primary reason why their rectal temperature increases at air temperatures from 70° to 80° and above. They dissipate excess body heat chiefly by increasing their rate of respiration. Much excess heat is lost through evaporation of water in the lungs.

Climatic Conditions In the Desert Regions

Imperial Valley, Coachella Valley, Palo Verde Valley, and other desert re-

* All temperatures in this bulletin are on the Fahrenheit scale.

gions of California have a mean monthly temperature above 75° for about six months of the year; for nearly four months it exceeds 85° and for two months it is 90°. June and part of July are dry; nights are comfortable. From about July 15 to September 20, the prevailing winds from the south and southeast bring moist air from the Gulf of Lower California, and minimum temperatures at night seldom drop below 70°; furthermore, they are seldom below 80° for more than four hours. Such conditions are oppressive to animals as well as to humans.

Temperature is of primary importance in summer livestock management. Figure 1 (page 4) presents average daily maximum and minimum temperatures and noon humidity between April and November, 1946–1952. Figure 2 gives the same data for 1946, showing more clearly how night temperatures rise above the critical temperature (the temperature beyond which cattle body heat rises above normal) and how night temperatures coincide with increased humidity in July and August. Most of the figures were compiled at Imperial Valley Field Station.*

Humidity is an important climatic element in the desert regions, but in a different way than might be supposed. The air becomes laden with moisture and tends to reflect heat back to the earth instead of letting it dissipate in the upper atmosphere. Since the soil cannot cool, night temperatures rise and the mean temperature for the 24-hour period goes above the critical point. Cattle body temperatures rise above normal, with consequent reduction of food consumption and decrease in beef and milk production.

What was learned during the studies made on dairy cattle

Reaction of Holsteins And Jerseys to Heat

Information for this study was collected from Imperial Valley dairymen in 1946. It substantiates laboratory findings and data from other countries.

Records of milk production, body temperatures, and respiration rates of 10 purebred Holstein cows were taken at an Imperial Valley dairy between May and November, 1946. Table 1 shows the inter-relationship of air temperature, milk production, body temperature, and respiration rate. The greatest drop in milk production came in July. The decrease was 11 pounds daily, or 23 per cent, compared with a 9 per cent drop between May and June. During May and October, body temperatures and respiration rates of the cows were normal in the afternoon; respiration rates ranged from 65 to 67 in the middle of the day. July and August were similar: body temperatures averaged 104.8° between 3 and 5 p.m.; respirations averaged from 67 per minute in the morning to 99 in the afternoon. September was cooler, but body temperature and respiration rates were above normal throughout the day and night.

To see if there is any difference in the way high- and low-producing cows react to high temperatures, data for the three highest-producing cows and the three lowest were segregated. In May and October they differed little, but during the other four months the high producers consistently averaged 0.3° to 0.8° higher in body temperature. Differences in respiration rates were not so definite, but the high producers tended to breathe more rapidly. (See table 2, page 9.)

* Imperial Irrigation District furnished the missing data.

Table 1. Average Milk Production, Body Temperatures, and Respiration Rates of Ten Holstein Cows

Date	Milk production	Body temp.		Respiration rate					Daily temp.	
		3–5 a.m.	3–5 p.m.	3–5 a.m.	10–11 a.m.	1–2 p.m.	3–5 p.m.	Av.	Maximum	Minimum
	pounds	deg. F.	deg. F						deg. F	deg. F
May 10	52.9	101.0	101.7	30	42	50	33	39	85	57
June 11 June 12	48.3	101.6	102.3	37	67	65	46	54	104 108	74 68
July 15	37.2	102.6	104.1	67	90	*	77	*	112	81
Aug. 8 Aug. 9	30.3	102.5	104.2	71	87	99	87	86	108 107	82 79
Sept. 6	27.9	102.4	103.4	50	75	75	52	63	108	71
Oct. 7 Oct. 8	22.2	101.0	101.6	29	46	49	38	41	86 86	50 50

* This reading was not taken.

Similar data were collected on five grade Holstein and five Jersey cows at another dairy; the results are shown in table 3. The Holsteins had higher body temperatures and higher respiration rates than the Jerseys, particularly during the hotter months. The Jerseys dropped 15.4 per cent in milk production in July, while the Holsteins dropped 27 per cent. From July 29 on, the two groups produced the same amount of milk. As in the first tests (table 2), the high-producing cows in both groups ran higher body temperatures and respiration rates than the low producers.

Color of a Cow's Coat Determines Heat Absorption

More radiant heat is reflected from a white surface than from a black one. Consequently, a light-coated cow in the sun absorbs less radiant heat than a dark-coated cow.

The relation of coat color to respiration rate in cows (a) exposed to direct sunlight and (b) under shade was studied at a Holstein dairy. The dairy kept dry cows and older heifers on pasture during the entire summer without access to shade. On August 8, between 11 a.m. and noon, with an air temperature of 102°, nine cows that were 80 per cent or more white had an average respiration of 105 per minute while five cows 80 per cent or more black had an average rate of 118. This difference is statistically significant. But when a similar test was made of cows under shade the difference was not statistically significant: On September 6, between 10 and 11 a.m.—the air temperature was 103°—ten predominantly white cows showed an average respiration rate of 76, and 10 predominantly black cows showed an average respiration rate of 70.

Dry cows, although they had fast respiration rates, did very little driveling compared to lactating cows.

How Temperature Affects Milk Production

To learn the effects of daily temperatures on milk production, three dairies were studied. Records of Dairies 1 and 2 covered June, July, and part of August; Dairy 3 records covered the months from June to November. Generally, these records give a good picture of Imperial Valley milk production during the summer.

Dairy 1 pastured its purebred Guernseys most of the year, but corral-fed them in summer. Most of its cows were bred so they would be in the later stages of lactation in summer. Shades provided were made of 10-foot galvanized iron sheets and were about 8 feet high. Dairy 2 had grade cows of all breeds with no particular freshening time. Tree shade was excellent and ample, and the cows were corral-fed (fig. 3). Dairy 3's high grade Guernseys were brought into the Valley in the spring of 1946. Its cows calved in the Valley, the last six in July. They were corral-fed in summer, and had good tree shade but not enough of it.

Dairy 1 kept the same number of cows through the test period, while Dairies 2 and 3 added and discarded cows from the milking string without recording dates.

Figure 4 shows that in Dairies 1 and 3 there was a decided drop in milk production on July 9, while No. 2 had a slight rise; its production began to fall off after July 9 but not as rapidly as in the other two. The production drop coincides with the rise in night tempera-

Table 2. Average Milk Production, Body Temperature, and Respiration Rate of the Three High-Producing Holstein Cows Compared to the Average of the Three Low-Producing Holsteins

Date	Production	Milk production	Milk production drop	Body temp. 3–5 a.m.	Body temp. 3–5 p.m.	Respiration rate per minute 3–5 a.m.	10–11 a.m.	1–2 p.m.	3–5 p.m.
		pounds	pounds	deg. F	deg. F				
May 10......	High	61.9*	....	101.2	101.6	29	49	53	33
	Low	44.8	....	101.1	101.8	32	40	51	34
June 11......	High	59.3	2.6	101.8	102.3	43	73	72	47
June 12......	Low	44.7	0.1	101.5	102.0	33	72	63	44
July 15.......	High	43.5	15.8	103.0	104.4	79	91	..	86
	Low	34.0	10.7	102.2	103.9	66	96	..	84
Aug. 8.......	High	37.1	6.4	102.6	104.4	70	89	107	89
Aug. 9.......	Low	27.2	6.8	102.0	103.9	77	91	99	87
Sept. 6.......	High	35.5	1.6	102.6	103.5	53	80	79	59
	Low	25.1	2.1	102.0	102.9	45	70	72	51
Oct. 7........	High	27.8	7.7	100.8	101.4	29	53	47	41
Oct. 8........	Low	16.4	8.7	101.2	101.7	30	41	51	41

* Records of production were used to differentiate between high- and low-producing cows and did not indicate the stage of lactation.

Table 3. Average Milk Production, Body Temperature, and Respiration Rate of Five Holstein-Type Cows Compared with Five Jersey-Type Cows

Date	Milk production—pounds	Body temp. in deg. F		Respiration rate				
		4–6 a.m.	4–6 p.m.	4–6 a.m.	10–11 a.m.	1–2 p.m.	4–6 p.m.	Average
Holstein Type								
May 14	43.3	101.3	101.9	30	60	54	40	46
June 17 June 18	37.4	101.5	102.4	51	56	72	51	58
July 22	27.3	102.6	104.0	74	..	..	96	..
July 29 July 30	24.3	101.7	103.3	65	105	109	85	91
Aug. 31	23.0	102.0	102.9	77	94	97	82	88
Oct. 3 Oct. 4	19.4	101.2	102.0	31	48	53	38	43
Jersey Type								
May 14	29.5	101.3	101.6	27	52	51	36	42
June 17 June 18	27.9	101.6	102.1	39	57	69	51	54
July 22	23.6	101.5	103.0	44	..	..	82	..
July 29 July 30	24.4	101.0	102.6	46	94	84	80	76
Aug. 31	23.2	101.3	102.2	54	76	75	72	69
Oct. 3 Oct. 4	19.5	101.4	101.5	23	36	50	30	35

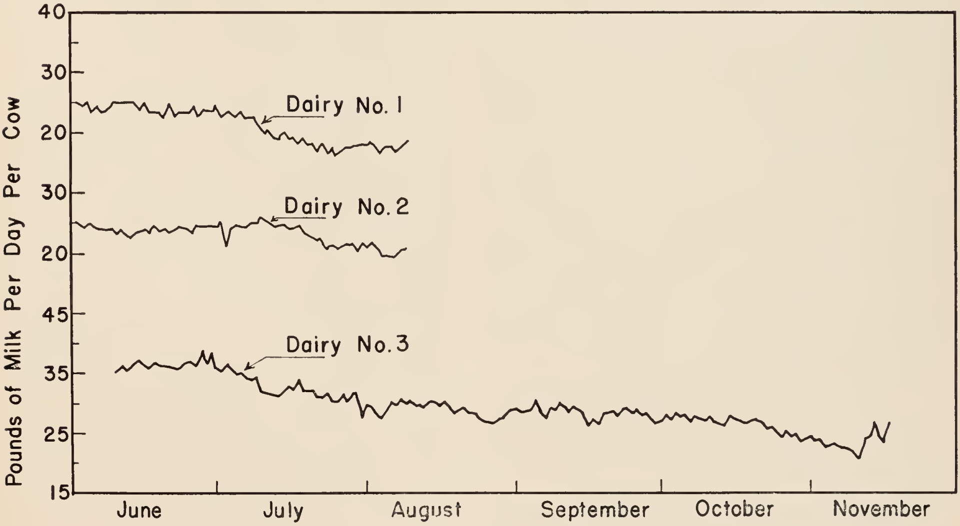
tures. From June 1 to July 9 the average minimum temperature was 66.5°, and from July 9 on—for the next 34 days—the average minimum was 79°, with only two nights below 75°.

Some dairymen report that cows freshening in summer show an increase in production when the cooler weather of autumn arrives. Dairy 3 did not show such a rise after the break in the hot weather, which came on October 1; in fact it showed a continued drop—perhaps due to advanced lactation—all through October. Records furnished by all three dairies showed several more marked drops in production after the

Fig. 3. These eucalyptus trees at Dairy No. 2 provided adequate shade for all cows during most of the day. It was not necessary for them to crowd together and make ground wet and muddy.

drop of July 9, and these seem to have coincided with hot nights when temperatures were above 75°. About November 10 all the cows of Dairy 3 were given good alfalfa pasture and production then increased. If green pasture could have been provided on October 1 the cows might have increased production at that time, since the weather was cool enough for them to make efficient use of it.

Fig. 4. Milk production records of the three dairy herds. The data shown here may be compared with weather data in figure 2 (bottom of page 4).



How Heat Affects Cow's Use of Pasture

The following observations were made to learn how summer heat affects the cow's use of pasture and to learn what changes it makes tō compensate for the heat.

One dairy herd, with access to pasture at all times, was observed during this period (May through October). The senior author made careful observations once a month and combined his findings with those of the owner of the herd. As summer approached the cows used the shade more and more. In May the first cows milked waited in the drylot for the others; then all the animals went out to graze at 7 a.m., for one hour. They rested from 8 to 9 and then grazed again. The first cow came into the drylot at 10; all were in by 11. They ate the hay fed them there, and then stood under the shade. Most lay down from 1 to 3 p.m., and most lay in the shade. The first cows of the milking string went out to graze at 4 p.m.; the others followed as soon as they were milked. The cows were always back in the drylot by 8:30 to 9 p.m. and spent the night there.

In June the first cows milked went right out to pasture at about 4:30 a.m., and the first cows were back in by 8. By 9 half the cows were in, but the last ones were not in until 11 a.m. In the evening the first string stayed around the drylot until 5 p.m. During the day about 10 per cent of the cows were lying in the sun.

During July, the first cows milked were on pasture by 4:40 a.m., but 60 per cent were in the drylot by 7, and all were in eating hay by 8:30. All the cattle were under the shade by 9:30. The cows ate very little after 9:30 during July and August. At night they did not go out to graze until a little after 5 p.m.

August was much the same as July. All the cows were in by 8:30 a.m., and all used the shade.

September was a little cooler, and the cows spent a little more time grazing. It was still dark when the first string finished; they remained around the drylot until 5 a.m., then started out to graze. The first ones came in at 9, and all were in at 10. In the evening the cows went out at 4:30 p.m.

In October the cows went out after sun-up, a little after 5 a.m. Many ate hay during the day, after coming in from the pasture. One day, for example, at 10 a.m., 30 cows were eating; 19 were in the sun and 11 were still on the pasture. All were in the drylot by 10:30 a.m.; at 1 p.m. 16 cows were eating, 74 were lying down, and 10 were in the sun. In the evening the cows went out to graze right after they were milked at 4 p.m. All showed considerably more life and seemed to have improved in appetite.

Discussion and Results

The climatic record (figures 1 and 2), shows that night temperature and humidity rose simultaneously and coincided with the first precipitous drop in milk production. The data concerning the relative effects of temperature and humidity seem to indicate that the rise in night temperature to above the critical temperature of the cattle was the primary factor causing body temperature to rise above normal, with consequent reduction of food consumption and decrease in production.

The data indicate that dry cows suffer less than lactating cows during the hot months. On the basis of the limited data in table 2, high-producing cows tend to have higher body temperatures and respiration rates than low producers. Yet there are reasons to presume that extremely high-producing cows must be more efficient heat-eliminators to dispose of the excess incident to heavy food consumption and milk production. The difference in heat tolerance of dry and producing cows confirms other observations. The explanation probably lies in the lower food consumption of dry cows.

The observation of significantly higher respiration rates in predominantly black animals compared to predominantly white ones exposed to direct sunlight agrees with data obtained in Louisiana and South Africa, where white or light-colored animals reflected 22 to 55 per cent of solar radiation compared with $2\frac{1}{2}$ to 10 per cent by black animals.

The comparison of Jerseys and Holsteins confirms work done at Davis and other stations that Jerseys are more heat-tolerant than Holsteins.

The Holstein cows made four adjustments to reduce their heat load during July and August: (1) They grazed early in the morning or after 5 p.m. to avoid direct rays of the sun. Most of their non-grazing time was spent under shade. (2) Nearly all cows stood up during the day, thus exposing all the surface possible for radiating excess heat and probably facilitating respiratory movement. (3) Very little hay was eaten during the middle of the day. This reduced their heat of digestion. (4) Although an accurate measurement of food consumption was impossible, there was an over-all drop that also cut down the heat generated by digestive processes.

What was learned about the reactions of beef cattle

Crossbreeding Tests Using Hereford Cows

To determine if there is any advantage in using Brahman bulls on Hereford cows in a warm climate that is nevertheless considered satisfactory for Hereford cattle, the following test was organized in cooperation with Louis H. Rochford, president and general manager of the Tejon Ranch, Bakersfield.

In 1946 Mr. Rochford selected 101 head of high quality Hereford cows and segregated them in a pasture. From March to September, 1947, two Brahman and two Hereford bulls were placed with these cows. The calves resulting from these matings were purchased by the University late in 1948 and transferred to the Imperial Valley Field Station. In 1948 two Brahman, two Hereford and two Shorthorn bulls were placed with the selected cows on the Tejon Ranch to provide for the additional comparison of Shorthorn-Hereford crossbreds. Calves from these matings were secured in the autumn of 1949. This procedure was followed again in the 1949 breeding season, and the last group was transferred to Imperial Valley in September, 1950.

Table 4 gives data on reproduction, numbers of purebred and crossbred calves obtained, and average weaning weights. Weaning weights of the Hereford, Braford, and Shorthorn x Hereford calves averaged 419 pounds. Lack of definite records at weaning age precludes conclusion on the significance of weight differences. Although this area is warm, there was no obvious evidence that the Hereford cows were under stress.

The average data for combined steers and heifers in 1949 are affected by variation in the steer-heifer ratio between groups. The six bulls were together in the pasture and had equal breeding opportunities. In this case at least, the Hereford bulls were the most aggressive and active.

All calves made good weaning weights (419 pounds average); the Hereford cows showed no particular stress from the heat, and in this test the Hereford bulls were more aggressive and active.

Winter Feedlot Test Comparisons

In addition to obtaining data to weaning at Tejon Ranch, the general plan

was to feed out part of the calves in Imperial Valley during the fall, winter, and spring, when climatic conditions presumably would favor all animals. This was expected to show any inherent differences in gaining and finishing ability and efficiency of feed utilization when none of the animals were subjected to environmental stress. The remaining cattle were fed on pasture and hay that winter and the following summer, and were finished out in the fall to obtain information on how they compared under hot summer temperatures. All of the 1950 calves were pastured through the winter and spring. The steers were finished in summer and sold in September, 1951.

For further comparison, steers and heifers of comparable age and carrying a high percentage of Brahman blood were purchased in 1949. These were much better than the average Brahman then available for feeding.

Table 5 presents data for steers and heifers from two feedlot tests of about 200 days each. These were on Brahmans, Herefords, Shorthorn x Herefords, and

Table 4. Record of Crossbreeding Test, Tejon Ranch, Bakersfield, California

	1948	1949	1950
Cows in breeding herd for calf crop	101	101†	99†
Number of bulls*	4	6	6
Calves weaned			
Hereford	57	44	42
Brahman-Hereford	36	31	25
Shorthorn-Hereford	...	26	16
TOTAL	93	101	83
Percentage calf crop	92.1	100	83.8
Weaning weights‡			
Hereford steers	452	...§	434
Brahman-Hereford steers	423	...	413
Shorthorn-Hereford steers	...	...	413
Hereford heifers	438	...	389
Brahman-Hereford heifers	430	...	395
Shorthorn-Hereford heifers	...	...	360

* The bulls consisted of two Hereford and two Brahman bulls all two years of age in 1947. In 1948 and 1949, two Hereford, two Brahman, and two Shorthorn bulls were used.

† During the 1949 breeding season there were 150 cows in the herd. Fifty-one head were sold subsequently.

‡ In 1948 the estimated average age of the Hereford steers was seven to eight months; the Hereford heifers seven months; the Brahman-Hereford steers and heifers seven months. Thus there may have been a slight advantage in age in favor of the Herefords. In 1949 the average age at weening was about seven months, and in 1950 about six months. The Shorthorn crossbreds average slightly younger in both years, and therefore were lighter at weaning than Herefords or Brafords. Both early and late calves were represented in all groups, but the Brahman and Shorthorn crosses were distributed more throughout the season than were the Herefords.

§ The steer and heifer calves were not weighed separately in 1949. The combined data for steers and heifers were as follows:

Hereford	18 steers, and 26 heifers, average weight 432 lbs.
Brahman-Hereford	14 steers, and 17 heifers, average weight 443 lbs.
Shorthorn-Hereford	16 steers, and 10 heifers, average weight 423 lbs.

Brafords. Table 6 gives these data for both sexes for the 1948–49 test. These figures are more reliable and offer a better comparison, although they cover only the last 104 days of the test. Table 7 contains 1949–50 data on steers and heifers, separately. Figure 5 shows the animals of table 6 at the end of the feeding trial.

Rate of Gain. Considering the steers and heifers in both winter trials (table 5), Herefords ranked first; Shorthorn x Herefords second; Brafords third; and Brahmans last—in rate and efficiency of gain and in feed consumption. When the sexes were considered separately in the first trial, the difference between the gain of the Hereford heifers and that of the Braford and Brahman heifers was highly significant. The difference between the Braford and Brahman heifers was doubtless real, but with the small numbers were not quite statistically significant at odds of 20 to 1 for the entire 205 days. During the last 104 days the difference in gain was greater and statistically significant (table 6).

The average gains of Hereford and Braford steers in the first trial were essentially equal; both were greater than that of the Brahmans. The difference was of borderline significance for the whole

Table 5. Results of Feed Lot Trials with Brahman, Hereford, Braford, and Shorthorn x Hereford Steers and Heifers

(All figures are in pounds unless otherwise indicated)

	1st year's test—205 days October 8, 1948–May 1, 1949			2nd year's test—197 days October 4, 1949–April 29, 1950		
	Brahman	Hereford	Braford	Hereford	Braford	S × H
No. of animals*	12	12	12	16	16	10
Av. initial wt.	433	501	504	492	487	455
Av. final wt.	767	934	896	922	860	873
AV. DAILY GAIN	1.64	2.15	1.91	2.18	1.89	2.10
Av. daily feed						
Grain†	4.68	6.78	6.23	5.63	5.53	5.48
Dry beet pulp	3.13	3.71	3.33	3.81	3.72	3.75
Alfalfa hay‡	6.88	8.61	8.45	5.34	5.22	5.39
Sudan and barley hay	.....	.....	.....	2.59	2.56	2.62
TOTAL	14.69	19.10	18.01	17.37	17.03	17.24
Feed/100 lb. gain						
Grain	285	315	326	258	292	260
Dry beet pulp	190	172	174	174	197	178
Alfalfa hay	396	379	416	245	276	256
Sudan and barley hay	.....	.....	.....	119	135	124
TOTAL	871	866	916	796	900	818

* The first year only 11 animals were in the Brahman and Hereford lots during the first 101 days. There were 12 head in each lot during the last period.

† The grain was barley although some milo was included in the ration during the last part of the first year's test.

‡ Some sudan hay and barley hay was fed with the alfalfa hay during the first year.

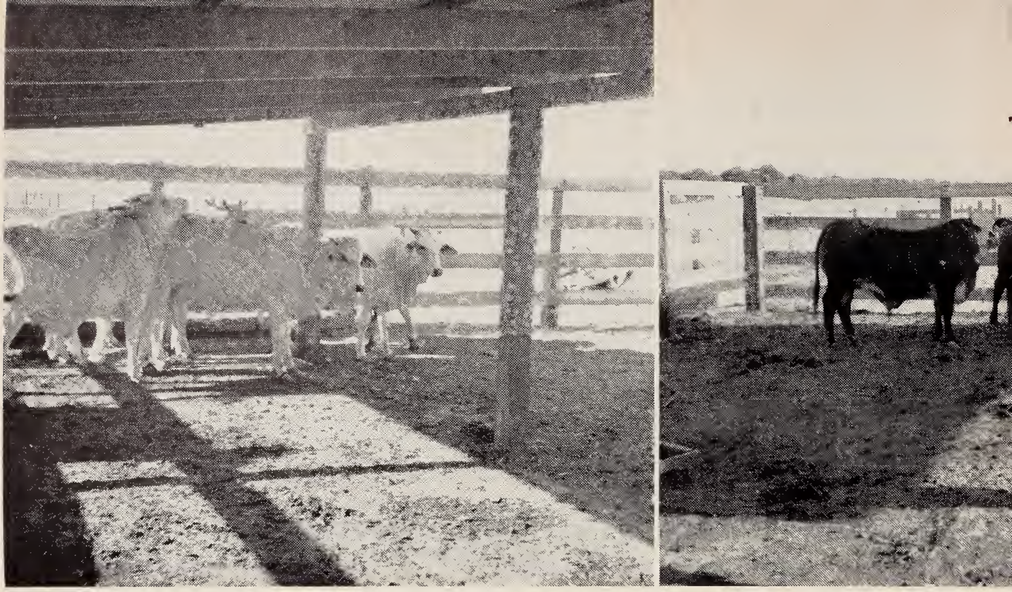
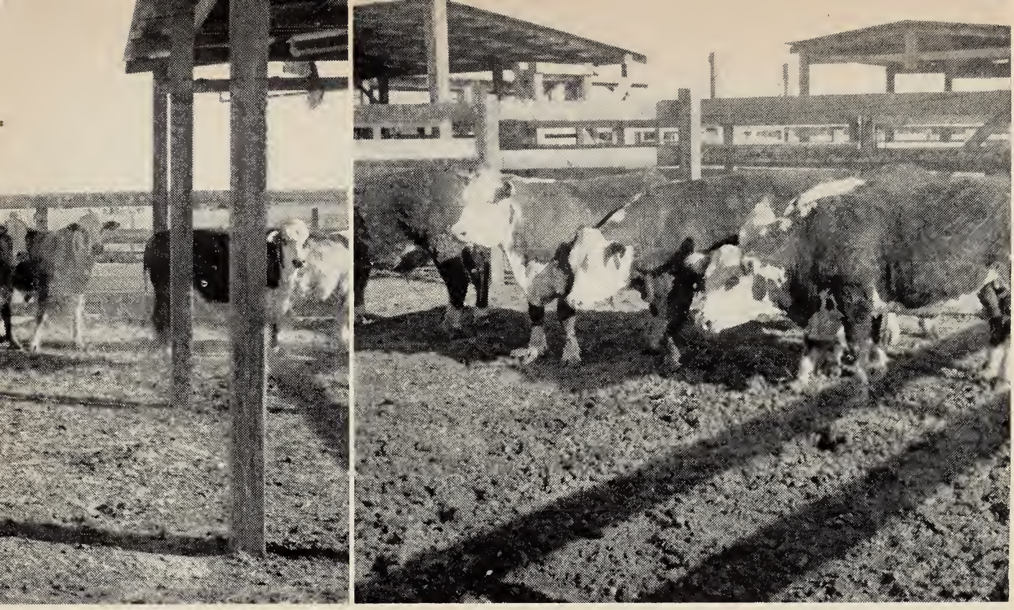


Fig. 5. From left to right are shown Brahman, Braford, and Hereford steers at the

Table 6. Comparison of Brahman, Hereford, and Braford Steers and Heifers During the Last 104 Days of the 205-Day Feeding Period Jan. 17, 1949–May 1, 1949

(All figures are in pounds unless otherwise indicated)

	Group 1 Brahman steers	Group 2 Brahman heifers	Group 3 Hereford steers	Group 4 Hereford heifers	Group 5 Braford steers	Group 6 Braford heifers
Number in lot	7	5	6	6	6	6
Av. initial wt.	641	567	713	719	743	634
Av. final wt.	816	698	943	924	979	814
AV. DAILY GAIN	1.68	1.26	2.21	1.97	2.26	1.73
Av. daily feed						
Barley	3.49	2.54	4.84	4.96	5.14	3.85
Milo	1.63	1.44	2.52	2.52	2.50	2.14
Dry beet pulp	4.06	3.85	4.59	4.86	4.94	3.65
Alfalfa hay	5.24	4.81	6.51	6.53	7.09	6.26
Barley hay	1.73	1.29	1.66	1.56	1.68	1.31
Feed/100 lb. gain						
Barley	207	202	219	252	227	223
Milo	97	114	114	128	110	124
Dry beet pulp	241	306	208	246	218	211
Alfalfa hay	311	382	295	330	313	362
Barley hay	103	103	75	79	74	76
TOTAL	959	1,107	911	1,035	942	996



onclusion of the 1948–1949 winter feeding test which was conducted for 205 days.

Table 7. Comparison of Braford, Hereford, Shorthorn x Hereford Steers and Heifers on Full Feed for the 197-Day Feeding Period, October 4, 1949–April 29, 1950

(All figures are in pounds unless otherwise indicated)

	Hereford steers	Hereford heifers	Braford steers	Braford heifers	S × H steers	S × H heifers
No. of animals	8	8	8	8	5	5
Av. initial wt.	504	479	474	499	471	437
Av. final wt.	959	884	859	860	912	835
AV. DAILY GAIN	2.31	2.06	1.96	1.83	2.19	2.02
Av. daily feed						
Barley	5.75	5.52	5.56	5.50	5.55	5.41
Dry beet pulp	3.88	3.73	3.74	3.71	3.80	3.70
Alfalfa hay	5.52	5.16	5.33	5.12	5.78	5.00
Sudan and barley hay	2.64	2.53	2.61	2.51	2.70	2.53
TOTAL	17.79	16.94	17.24	16.84	17.83	16.64
Feed/100 lb. gain						
Barley	249	268	284	300	254	268
Dry beet pulp	168	182	191	202	174	183
Alfalfa hay	239	251	272	280	264	248
Sudan and barley hay	114	123	133	137	124	125
TOTAL	770	824	880	919	816	824

period but was highly significant during the last 104 days of the test (table 6).

In the 1949–1950 trials (table 7) there was no great difference between the gains of the Herefords and the Shorthorn x Hereford crossbreds, although the latter averaged slightly lower. The gains of the Herefords, both steers and heifers, were significantly larger than the Brafords'.

The steers and heifers were fed for equal periods in each trial, and since the heifers are faster maturing they were fatter at slaughter time as the carcass data show. The Hereford heifers, particularly, were highly finished, were ready for marketing several weeks before the steers, and their rate of gain declined during the last of the feeding period.

Both the Braford and Brahman heifer groups in the first trial were nervous and excitable; doubtless this fact affected their gains. The Braford steers quieted down after getting on feed. The Brahman steers, although alert and active, had quiet dispositions and most of them appreciated petting.

Economy of Gain. There was no significant difference in feed cost for 100 pounds gain between the Herefords and Shorthorn-Hereford crossbreds. Both of these groups required less feed per pound of gain than the Brafords and Brahmans. This appears to be highly significant, since not only did the Herefords and Shorthorn x Herefords require less total feed per pound of gain but also their gain contained somewhat more fat, which has a higher energy content than lean tissues. The higher carcass yield of the Brahmans and Brafords may offset their apparently lower efficiency based on live-weight gain.

The feed cost for 100 pounds of gain was uniformly greater for the heifers than for the corresponding steers. This may be accounted for by the higher average degree of fatness of the heifers. When two such groups are fed to equal finish, and the heifers marketed earlier, there is usually no significant difference in economy of gain compared with steers of similar age and breeding.

Feeding Habits. Herefords and Brahmans exhibited a marked difference in the way they consumed feed. The latter ate more slowly and not so much at one time, while the Herefords gulped their grain. The Braford cattle ate more like the Herefords. The average daily food consumption for each 100 pounds live weight in both trials was: Brahman, 2.21; Braford, 2.48; Hereford, 2.46; and Shorthorn-Hereford cross, 2.60.

Some bloating occurred during the first trial. It was more noticeable among the Brahmans but not severe and apparently had little effect on gain.

These two feed lot tests show that Herefords ranked first; Shorthorn x Herefords second; Brafords third; and Brahmans last in rate and efficiency of gain and in feed consumption. Feed cost for 100 pounds of gain between the Herefords and Shorthorn-Hereford crossbreds were about the same and both these groups required less feed per pound of gain than the Brafords and Brahmans. However, the higher carcass yield of the Brafords and Brahmans may offset this lower efficiency of gain.

Summer Feedlot Test Comparisons

Only the steer calves from the 1950 group were fed out during the summer; the heifers were used for other tests. Table 8 summarizes this feeding trial. Figure 6 shows the Brafords and Shorthorn x Herefords at the end of the experiment.

Rates of gain. Over-all results were good for the one drylot summer feeding trial. Braford, Hereford, and Shorthorn x Hereford steers all gained a little more than two pounds daily. High summer temperatures definitely affected these gains during July and August. The Brafords and Herefords had a daily gain of

Fig. 6. (Left) Braford and (right) Shorthorn x Hereford steers at the conclusion of the 122-day summer feeding test period.

Table 8. Summer Comparison of Braford, Hereford, Shorthorn x Hereford Steers on Full Feed for 122 Days, May 15–September 14, 1951

(All figures are in pounds unless otherwise indicated)

	Mid-summer July 10–Sept. 3			Summer May 15–Sept. 14		
	Braford	Hereford	S × H	Braford	Hereford	S × H
No. of animals	10	8	6	10	8	6
Av. initial wt.	905	970	958	759	824	812
Av. final wt.	1,006	1,070	1,039	1,027	1,087	1,067
AV. DAILY GAIN	1.80	1.79	1.45	2.20	2.15	2.09
Av. daily feed						
Barley	5.73	5.73	5.40	5.54	5.38	5.37
Dry beet pulp	3.86	4.06	3.32	3.63	3.72	3.32
Alfalfa hay	10.77	9.60	6.11	11.33	10.74	9.16
Barley hay	1.89	2.34	4.03	1.98	2.36	3.53
TOTAL	22.25	21.73	18.86	22.48	22.20	21.38
Feed/100 lb. gain						
Barley	318	320	373	252	250	257
Dry beet pulp	214	227	229	165	173	159
Alfalfa hay	598	536	421	516	499	438
Barley hay	105	131	278	90	110	169
TOTAL	1,235	1,214	1,301	1,023	1,032	1,023

1.80 and 1.79 pounds respectively. The Shorthorn x Herefords gained only 1.45 pounds and showed more distress (table 8).

Economy of gain. For the three breeds of steers the economy of gain in the summer feeding trial was almost identical. To make 100 pounds of gain during mid-summer, the Brafords and Herefords needed about 200 pounds more feed and the Shorthorn x Herefords about 300 pounds more than the same groups needed for a 100-pound gain in the over-all period (May 15–Sept. 14). Although strictly comparable data are not available, tables 6, 7, and 8 indicate that more feed is required for a pound of gain in summer than in winter.

Feeding habits. The Shorthorn x Hereford steers consumed less feed in July and August. It was a problem to keep them on feed. In the evening they often had to be driven to the feed trough. They showed marked distress, but the Braford and Hereford groups did not seem especially uncomfortable. The Herefords had a faster respiration rate than the Brafords. Both of these lots were always ready to eat at feeding time, and the Herefords' food consumption was very close to that of the Brafords (table 8).

Tests on Pasture— Summer and Winter

Comparison of Hereford, Braford and Shorthorn x Hereford cattle: Tests were conducted at the Field Station to compare pasture and roughage utilization during the seasons, particularly in the hot summers. Pastures vary at different times of the year in Imperial Valley. Alfalfa is the most common irrigated-pasture crop. Many livestock men renovate, fertilize, and then plant barley or oats in their alfalfa fields about October 1 for winter pasture, and it is usually ready for grazing about December 1.

Livestock gains in December and January are often less than in the spring. This difference is due partly to the excess of water in feed at that time. Spring pastures in the Valley are exceptionally strong; cattle often make gains of 1.75 to 2 pounds per head per day. In summer the pasture growth slows somewhat, and there is always the danger of scalding alfalfa on the heavier soils.

The pasture tests were as follows:

Group 1 consisted of 12 Herefords and 12 Braford calves from the Tejon Ranch, each lot including six steers and six heifers. These animals were received December 7, 1948. The data are summarized in tables 9 and 10.

Group 2—Tejon Ranch yearlings—consisted of 16 Hereford and eight Braford steers, purchased May 5, 1949. Data are in tables 11 and 12.

Group 3, the last lot of cattle received from Tejon Ranch, were pastured from September 27 to May 15, and the steers were fed in the dry lot during the summer (table 8).

Conclusions

This summer feedlot experiment shows that Herefords can make good gains during the summer if they have good shades and airy corrals. Daily gains drop somewhat in July and August and the feed required per 100 pounds of gain is higher for summer than for winter feeding, but Brafords, Herefords, and Shorthorn x Herefords all required about the same amount of feed per 100 pounds of gain during this period. Shorthorn x Herefords showed considerable distress during July and August and were hard to keep on feed.

In the summer of 1948 a preliminary test was made with a fourth group. Eight head of good quality Braford steers from Texas were compared with 21 Hereford steer calves transferred from the San Joaquin Experimental Range herd. The Hereford calves were born the preceding fall, while the Brafords presumably were several months older. Since these cattle were fed to-

Table 9. Comparative Seasonal Gains of Herefords and Brafords (1948–1949)

(All figures are in pounds unless otherwise indicated)

	Winter, hay in dry lot Dec. 7–March 4 (88 days)	Spring, pasture March 5–June 13 (101 days)	Summer, pasture June 14–Sept. 14 (93 days)	Fall, hay and grain in dry lot Sept. 15–Oct. 22 (37 days)	Average all periods (319 days)
Hereford steers 6 head					
Av. initial wt.	510	655	839	987	
Av. final wt.	655	839	987	1,080	
AV. DAILY GAIN	1.65	1.82	1.58	2.51	1.79
Hereford heifers 6 head					
Av. initial wt.	513	629	802	939	
Av. final wt.	629	802	939	1,015	
AV. DAILY GAIN	1.32	1.71	1.47	2.08	1.57
Braford steers 6 head					
Av. initial wt.	461	598	815	1,006	
Av. final wt.	598	815	1,006	1,090	
AV. DAILY GAIN	1.56	2.15	2.05	2.29	1.97
Braford heifers 6 head					
Av. initial wt.	444	558	744	912	
Av. final wt.	558	744	912	993	
AV. DAILY GAIN	1.30	1.84	1.80	2.19	1.72
Av. 24 head					
Av. initial wt.	528	610	800	961	
Av. final wt.	610	800	961	1,045	
AV. DAILY GAIN	1.47	1.89	1.73	2.27	1.80
Av. daily feed*					
Alfalfa and grain hay	18.49	3.44	3.45	11.02	7.35
Concentrates	......	......	......	6.53	0.84
Feed/100 lb. gain*					
Alfalfa and grain hay	1,259	183	200	486	408
Concentrates	......	......	......	288†	46.8

* Feed records do not include the first 32 days of the test.
† Barley and beet pulp was the concentrate feed during this period.

Table 10. Sale and Slaughter Data on Braford and Hereford Steers and Heifers (1948–1949)

	Braford steers	Hereford steers	Braford heifers	Hereford heifers
No. of animals	6	6	6	6
Av. wt. at home, lb	1,090	1,080	993	1,015
Percent shrink to Los Angeles	4.93	5.53	5.98	5.14
Percent shrink on selling wt.	3.33	3.06	3.71	1.28*
Selling price, cents	25.25	26.50	24.00	24.00
Grade	5 good, 1 comm.	6 good	5 good, 1 comm.	Not graded
Dressing percentage (3 percent shrink)	61.47	59.35	62.51	58.94

* The Hereford heifers were not sold until 11 a.m. and had taken on a good fill. The other groups were sold early in the morning.

gether, no comparative feed consumption data were obtained. For the period of hot weather, July 28 to September 20, the Brafords gained at the rate of 1.99 pounds daily, the Herefords 0.85. The final weight of the Brafords was 691 pounds, the Herefords', 591. The difference in initial weights averaged 41 pounds.

Group 1. During winter dry-lot feeding on hay the 12 Herefords outgained the 12 Brafords. In the spring and summer pasture period the situation was reversed, the difference being greatest during the hot weather, June to September. The average consumption of dry hay in addition to pasture for both groups was 3.4 pounds per head daily. The pasture was mainly alfalfa with a small amount of alta fescue. These cattle were marketed in October after 37 days in dry lot on a hay and grain ration. The total gain for the 319-day period was: Hereford steers, 570 pounds; Braford steers, 629 pounds; Hereford heifers, 502 pounds; and Braford heifers, 549 pounds. All cattle except one Braford steer and one Braford heifer graded good (grade description prior to 1951). The total average concentrates used per head was 242 pounds (table 9).

This test shows the possibilities for producing good grade long yearling beef with a minimum of concentrates through promotion of continuous growth and development after weaning by wintering well and providing good pasture during the summer, followed by a short dry-lot period in the fall. Producing quality beef with a minimum of concentrates is a major problem facing future beef production.

Herefords proved more efficient on full feed in dry lot both in this and in the dry-lot feeding trials. Brafords outgained Herefords, however, on pasture during both the moderate and high temperature periods. Their average daily gain on pasture and roughage was comparable to that of their mates on full feed of concentrates in dry lot during the fall, winter, and spring (tables 5, 6, and 7). It is possible the Brafords and Herefords were not equally adapted during the winter even under the very mild conditions of Imperial Valley. The indications are, however, that Brafords were especially efficient in pasture ulitization.

From August 5 to September 14, when day and night temperatures were high, there was a drop in gain of all lots as shown by the tabulation on page 23.

Average Daily Gain—in Pounds

	Hereford Steers	*Hereford Heifers*	*Braford Steers*	*Braford Heifers*
June 14–Aug. 4	2.03	1.71	2.60	2.28
Aug. 5–Sept. 14	1.02	1.15	1.35	1.20
Difference	0.91	0.56	1.25	1.08

Quality of pasture as well as climatic conditions may have been involved. It would seem that during the extreme heat of summer (Aug. 5–Sept. 14) the Brafords were somewhat affected by high temperatures, although not as much as the Herefords.

Sale and slaughter data are in table 10. Again there was no consistent difference in transit shrinkage between Herefords and Brafords. Considering the difference in yield of more than 2 per cent in favor of the Brafords and the carcass data (see page 31), the spread of $1.25

Table 11. Comparative Seasonal Gains of Hereford and Braford Steers (1949–1950)

	Spring pasture: May 13–June 9 (28 days)	Summer pasture: June 10–Sept. 15 (98 days)	Fall, hay in dry lot: Sept. 16–Nov. 1 (47 days)	Winter hay and grain dry lot: Nov. 2–Jan. 7 (66 days)	Average of all periods (239 days)
Hereford steers (16 head)					
Av. initial wt.	549	601	727	825	
Av. final wt.	601	727	825	967	
AV. DAILY GAIN	1.89	1.28	2.07	2.16	1.75
Braford steers (8 head)					
Av. initial wt.	481	530	729	831*	
Av. final wt.	530	729	828	960	
AV. DAILY GAIN	1.74	2.03	2.33	1.95	2.04
Av. of 24 head					
Av. initial wt.	526	578	728	827*	
Av. final wt.	578	728	829	965	
AV. DAILY GAIN	1.84	1.53	2.16	2.10	1.84
Av. daily feed					
Alfalfa and grain hay	3.54	6.70	25.7	24.11	14.77
Concentrates	......	......	......	9.63	2.57
Feed/100 lb. gain					
Alfalfa and grain hay	193	437	1,192	1,151	801
Concentrates	......	......	......	460†	140

* Only 7 Brafords during feeding period. One animal was sold.
† A barley-and-beet-pulp concentrate was fed during this period.

per hundred pounds in favor of the Herefords was probably not justified.

Group 2. As table 11 shows, Herefords outgained Brafords slightly during spring pasturing. During the hot weather (June to September), however, there was a conspicuous difference in favor of the Brafords and also, to a lesser extent, during the fall period on roughage consisting of alfalfa and grain hay. The gains of 2.07 and 2.33 pounds respectively for the Herefords and Brafords on roughage alone were remarkable during this 47-day period. Other records at the Station showing gains higher than normally expected by young animals on roughage alone emphasize the possibilities of high-quality hay and suggest the need for an explanation.

These cattle were marketed in January, 1950, through the Los Angeles Union Stock Yards. Although they carried about the same finish as those sold the previous October, they were held by the buyer for further feeding, and no slaughter data were obtained. The selling data are shown in table 12.

Evidence from these trials indicates that Hereford cattle brought into the area during the fall and gradually accustomed to the climate do better during subsequent hot weather than those brought in early in summer.

Group 3. From September 25 to October 24, all 58 animals grazed on individual plots of Sudangrass, tall fescue, Hardinggrass, Dallisgrass, Rhodesgrass, blue panica, Paragrass and Napiergrass. The European cattle did poorly, averaging from 0.10 pound of gain per head per day for Hereford steers to 0.47 pound per day for Shorthorn x Hereford heifers. Braford steers and heifers averaged about a pound a day. This again shows how Brafords efficiently use rather poor quality pasture.

After the first month this group had good alfalfa pasture or alfalfa with barley planted in it for winter grazing. In the spring all the animals were on fescue pasture for not more than eight days when other pastures were too wet to graze. Steers and heifers were pastured separately during the spring except for the eight-day period on fescue.

Table 13 shows comparative seasonal gains of Hereford, Braford, and Shorthorn x Hereford steers and heifers for fall, winter, and spring pasture periods. The steers were fed out during the summer as reported previously, while the heifers were retained for other tests. The hay and grain fed these animals while on pasture during the three seasons (table 14) ranged from 3.73 to 4.85 pounds of hay per head per day, with a very small amount of barley.

The fall grazing period showed an average gain of 0.84 pounds per head per day for all animals. This poor showing was due partly to the poor pasture dur-

Table 12. Selling Data on Braford and Hereford Steers

	Braford steers	Hereford steers
No. of animals	7	16
Av. wt. at home—pounds	960	967
Percent shrink on selling weight	6.22	5.91
Selling price for hundred pounds, dollars	24.50	25.00

Note: The Hereford steers carried the same finish as those in the 1948–1949 group; however, these went to a packer for further feeding. Hence slaughter data were not obtained from this group.

Table 13. Comparative Seasonal Gains of Hereford, Braford, and Shorthorn x Hereford Steers and Heifers (1950–1951)

(All figures are in pounds unless otherwise indicated)

Steers	Fall pasture period 56 days Sept. 27–Nov. 21, 1950			Winter pasture period 91 days Nov. 22–Feb. 20, 1950–51			Spring pasture period 83 days Feb. 21–May 15, 1951		
	Hereford	Braford	S × H	Hereford	Braford	S × H	Hereford	Braford	S × H
No. of animals	10	10	6	9*	10	6	9	10	6
Av. initial wt.	472	398	430	505	453	476	656	606	647
Av. final wt.	507	453	476	656	606	647	818	759	812
AV. DAILY GAIN	0.63	0.98	0.83	1.66	1.68	1.88	1.95	1.84	1.98
Heifers	**Fall pasture period 56 days Sept. 27–Nov. 21, 1951**			**Winter pasture period 91 days Nov. 22–Feb. 20, 1950–51**			**Spring pasture period 85 days Feb. 21–May 17, 1951**		
	Hereford	Braford	S × H	Hereford	Braford	S × H	Hereford	Braford	S × H
No. of animals	12	12	8	12	12	8	10†	10†	8
Av. initial wt.	427	402	367	462	460	420	615	596	573
Av. final wt.	462	460	420	616	591	573	771	727	725
AV. DAILY GAIN	0.63	1.04	0.95	1.68	1.44	1.69	1.83	1.54	1.78

* One Hereford died.
† Two Hereford and two Braford heifers were removed on weigh day for other tests.

ing the first month. In winter when the animals were on alfalfa and barley pasture they averaged 1.65 pounds per day but in spring the steers made 1.91 pounds while the heifers gained 1.71 pounds per day.

During 231 days on pasture these animals gained 351 pounds per animal, average weight for the period being 592 pounds. They required about one acre per animal. After April 20, 1953, the pastures began to produce more than they could consume, and by May 15, when this phase of the test was completed, some of the plots were cut for hay.

In these four tests Brafords made daily gains of 0.3 to 1.1 pounds more than Herefords during the summer pasture period. The dry-lot feeding trials at the conclusion of these pasture tests again showed the Herefords more efficient. Several periods in these tests showed that Brafords were very efficient in their use of poor quality pasture. All groups made gains of 1.5–2.0 pounds daily during winter and spring pasturing. Gains of 2.0 pounds a day on roughage alone indicate that at least some of the hay had a high feeding value.

Alfalfa Pasture Better than Alta Fescue

Alfalfa is the major irrigated-pasture crop in the desert, and Imperial Valley usually has some 160,000 acres every year. Alta fescue, under test on this Station for a number of years, showed enough promise to warrant a field test. In September, 1950, a 20-acre pasture was planted in 6-inch rows at the rate of 10 pounds of seed per acre, and a good

Table 14. Seasonal Food Consumption for Animals in Table 13 (1950–1951)

(All figures are in pounds unless otherwise indicated)

	Fall	Winter	Spring	
	Sept. 27–Nov. 21 56 days	Nov. 22–Feb. 20 91 days	Steers Feb. 21–May 15 83 days	Heifers Feb. 21–May 17 85 days
No. of animals	58	57	25	28
Av. initial wt.	417	464	634	596
Av. final wt.	464	613	793	742
AV. DAILY GAIN	0.84	1.65	1.91	1.71
Av. daily feed				
Barley	0.63	1.77	0.34	0.33
Alfalfa hay	4.17	2.11	3.39	4.52
Barley hay	0.12	1.00	....	....
TOTAL	4.92	4.88	3.73	4.85
Feed/100 lb. gain				
Barley	74	107	18	19
Alfalfa hay	497	128	177	264
Barley hay	15	61	....	....
TOTAL	586	296	195	283

Table 15. Comparison of Fescue and Alfalfa Pasture with Hereford Steers, December 14, 1951–June 18, 1952

(All figures are in pounds unless otherwise indicated)

	Fescue			Alfalfa		
	Winter Dec. 14–Feb. 7 56 days	Early spring Feb. 8*–March 24 46 days	Spring March 25–June 17 84 days	Winter Dec. 14–Feb. 7 56 days	Early spring Feb. 8–March 24 46 days	Spring March 25–June 18 85 days
No. of animals	21	21	21	21	21	21
Av. initial wt.	472.1	529.6	623.5	472.4	556.6	650.8
Av. final wt.	529.6	623.4	694.8	556.6	650.7	768.0
AV. DAILY GAIN	1.03	2.04	0.85†	1.53	2.05	1.38†
Av. daily feed						
Alfalfa hay	.....	12.02	.....	.....	.....	.....
Barley hay	4.22	2.87	3.08	3.65	2.05	2.70
Barley and milo	0.92	0.54	.....	0.95	0.54	.....
TOTAL	5.14	15.43	3.08	4.60	2.59	2.70
Feed/100 lb. gain						
Alfalfa hay	.....	589	.....	.....	.....	.....
Barley hay	411	141	363	239	100	196
Barley and milo	90	27	.....	62	27	.....
TOTAL	501	757	363	301	127	196

* Between February 8 and March 24 the fescue steers were fed alfalfa hay in dry lot—no growth on the fescue.

† During the time on pasture the fescue steers' average gain was 0.92 lb. while the alfalfa steers' gain was 1.62 lb. per head per day.

stand was produced. In the fall of 1951 a pasture study was started comparing the fescue with an alfalfa pasture that was renovated in late September and reseeded with 5 pounds of alfalfa, 20 pounds of oats, 20 pounds of barley, and 20 pounds of wheat per acre for winter pasture. At the time this field was seeded it was fertilized with 100 pounds of 46 per cent phosphate and then irrigated on October 6. The fescue pasture was fertilized three times during the pasture period and each time received 40 pounds of nitrogen per acre.

In early November, 42 head of good quality Hereford steers averaging 450 pounds were secured. Between November 21 and December 14, all 42 steers were pastured on fescue since the alfalfa pasture was not quite mature enough for grazing. The animals made an average daily gain of 0.87 pounds per head per day and received 2.30 pounds of barley hay and 0.42 pounds of barley per head per day in addition to their pasture.

On December 14 all animals were weighed again and divided into two groups—one group going on the 20 acres of fescue and the other on the 20 acres of alfalfa and grain. Results of this test are shown in table 15. Between February 8 and March 24 the weather was rather cold and the fescue made little growth; so the fescue steers were fed alfalfa hay in dry lot for this 46-day period. During this period on hay the fescue group

gained 2.04 pounds per head per day, but the group on alfalfa and grain pasture made 2.05 pounds with 2.59 pounds of supplemental feed.

When both groups were on pasture the alfalfa lot consistently averaged a half pound more gain per head per day than the fescue group. Counting the original 23 days when all the animals were on the fescue pasture, the fescue produced 3,528 pounds of beef, while the alfalfa produced 6,197 pounds during these 187 days with almost the same amount of supplemental feed. Figure 7 shows fescue and alfalfa steers at the end of the test.

The fescue pasture, slightly smaller than the alfalfa field, measured 15.8 net acres; the alfalfa plot had 16.9 acres. Thus the fescue field, during the time the cattle were pastured (140 days), had 1.33 head of 548-pound animals per acre, and the alfalfa pasture had 1.24 head per acre of 579-pound animals until April 18. From April 18 to June 18 the 21 head of steers were pastured on only 10 acres of alfalfa, and during this time 2.1 head of 721-pound animals were pastured per acre. The pounds of beef produced per acre is the final yardstick of any pasture experiment. Thus the fescue field produced 223 pounds of beef per acre while the alfalfa pasture made 422 pounds of beef per acre. Since only 10 acres of the 17 acres of alfalfa pasture was utilized during the last 60 days of the test there was only an average of 14.7 acres actually used for the experiment. This would give the alfalfa pasture a carrying capacity of 1.43 head per acre of 620-pound animals for 187 days, with an average of 3.19 pounds of supplemental feed per day.

Recent work by Station Agronomist Shofner B. Boswell (now at Riverside Experiment Station) and Dr. M. L. Peterson, of the Department of Agronomy at Davis, showed Africa alfalfa to have a yield per acre of 102,500 pounds green weight for 10 clippings during the year; the five fescues tested showed a yield range of green material from 42,000 to 70,800 pounds with the same number of clippings. Fescue 144 was the high yielder followed by alta fescue, Kentucky 31 fescue, Goar's fescue and 4-36 fescue.

Considering daily gains, carrying capacity, beef produced per acre and production of green forage as shown by clipping tests, it is apparent that alfalfa pasture is superior to alta fescue in this area.

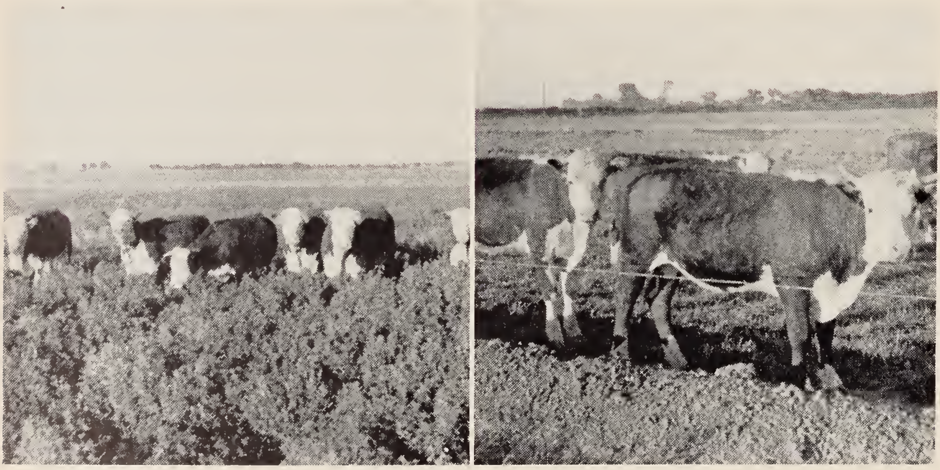


Fig. 7. (Left) Hereford steers pastured on alfalfa and alfalfa and grain and (right) steers pastured on fescue; both at the end of the winter feeding tests.

Tropical Grasses Seem Unsuitable

Two tropical grasses were tested in one-acre plots and grazed by cattle for two years: Paragrass (*Panicum purpurascens*), which grows in Florida, southern Texas and other Gulf states; and Napiergrass (*Pennisetum purpureum*), also called Elephantgrass—a native of Africa. Napiergrass is a perennial with much the same habits as sugar cane.

These grasses are perennials but are dormant all winter. Although they furnish some pasture from May to the middle of November, their rate of growth is quite slow except in July and August. Cattle like both grasses but because of their limited production the grasses do not seem well suited to Imperial Valley and similar regions.

Summer Grazing Habits of Beef Cattle

Experiment station personnel in many parts of the world have observed that Brahmans and their crosses spend more time grazing on hot summer days than do European breeds. To check these observations under local climatic conditions, a herd composed of Brahmans, cross-bred Brahmans, Santa Gertrudis type, Herefords, and Shorthorns was observed from April through October, between 5 a.m. and 6 p.m. All of the cattle had access to a large drylot with adequate shade.

In April and May all animals had four observable grazing periods. The first was from early morning until about 7 a.m. The time between 7 and 9 a.m. was spent in the drylot, and many of the Herefords and Shorthorns spent this time under the shade. The second grazing period was between 9 and 10:30 a.m.; from then until 1 p.m. the animals rested in the drylot. All of them grazed a third time between 1 and 2 p.m., resting in the pasture about two hours thereafter. At 4 p.m. they grazed again, until 6 p.m. After May 16 many of the Herefords and Shorthorns missed this third grazing period and did not go out to graze until about 4 p.m.

Differences develop. In June a difference in grazing habits of the various breeds began to develop. Almost all of the Herefords and Shorthorns were in the drylot by 7 a.m., then the Santa Gertrudis came in, and last of all the Brahmans. All cattle were in by 9 a.m. Most stayed in the drylot until 1:30 p.m. missing their second grazing period. About half of the cattle grazed for one-half hour; then all Herefords and Shorthorns came back to the shade, and many of the others lay down in the pasture. By 3 p.m. half of the Brahmans were grazing but all Herefords and Shorthorns were still under the shades. At 3 p.m. half of the Brahmans were grazing but all Herefords and Shorthorns were still in the shade, and 80 per cent of them were lying down. By 3:30 p.m., 90 per cent of the animals were grazing, and at 4:30 p.m. all were grazing.

Grazing habits for July and August were similar but most of the observations were taken in August. All the animals were in the drylot by 8 a.m. and their order of arrival was the same as in June. Most stayed in the drylot until 1 p.m.; then 75 per cent of the Brahmans and 20 per cent of the Santa Gertrudis grazed for a while. Some rested in the pasture while others came back to the drylot. After 4 p.m. the Herefords and Shorthorns began going out to graze.

September was much like June: the Herefords and Shorthorns did not begin to graze until after 4 p.m. While October was somewhat like May, the October pasture was very short and considerable hay was being fed so it was difficult to make comparisons.

These observations show that the Herefords and Shorthorns spent most of the time between 7 a.m. and 4 p.m. under the shades during July and August. Some of the Brahmans lay in the sun and all

Table 16. Respiration Rate of Brahman, Hereford, and Shorthorn Cows
Average of 400 Observations

Date	Time	75% Brahman	50% Brahman	25% Brahman	Hereford	Shorthorn	Daily temperature		Ave.† air temp.	Mean daily temp.
							Maximum	Minimum		
							deg. F	deg. F	deg. F	deg. F
May 31	5–6 a.m.	27*	..	..	42	45	103	64	70	83.5
	8–9 a.m.	44*	..	..	68	73	103	64	88	83.5
	10–11 a.m.	39*	..	..	73	76	103	64	96	83.5
	1–2 p.m.	38*	..	..	74	91	103	64	99	83.5
	3–4 p.m.	46*	..	..	82	91	103	64	98	83.5
June 28	10–11 a.m.	39*	..	..	76	93	105	64	96	84.5
June 29	Noon–1 p.m.	48*	..	..	76	95	104	67	100	85.5
Aug. 21	6–8 a.m.	33	49	53	65	72	107	82	90	94.5
Aug. 7	8–10 a.m.	53*	..	54	104	83	107	77	97	92.0
Aug. 14	9–10 a.m.	38	66	85	105	111	105	76	94	90.5
Aug. 19	9–11 a.m.	40	68	85	104	93	103	83	88	93.0
Aug. 6	3–4 p.m.	48*	..	78	109	98	107	77	104	92.0
Aug. 7	4–5 p.m.	36	76	79	115	91	107	77	104	92.0
Oct. 24	9–10 a.m.	27	38	50	67	73	90	53	80	71.5
Oct. 23	1–3 p.m.	29	32	42	73	81	92	50	91	71.0

* These figures include the 50% Brahmans.
† Average air temperature at time respirations were taken.

of them spent more time grazing than the Herefords and Shorthorns but many of them used the shades at some time during the day.

Herefords and Shorthorns spent most of their time standing in the shade during July and August, while the Brahmans spent much of their resting period lying down, although the time spent thus was not as great as in cooler months. This standing during the heat of the day probably facilitates respiratory movement and the evaporative cooling rate of the animal.

Respiration rates. During the above observations a series of respiration rates were taken on the different breeds and crossbreds in this herd. These rates are reported in table 16. The data show that the rate of respiration increases as the per cent of Brahman blood decreases. Herefords had a lower respiration rate than Shorthorns during the first part of the summer but it was higher after August 19. However, the Shorthorns became quite thin while the Herefords remained fat, which partially explains why they had a lower respiration rate than the Herefords. As noted above, Herefords have been shown to be more heat-tolerant than Shorthorns.

Measurements—A New Yardstick

The selection and evaluation of animals is usually done by the eye and experience of the animal husbandman. In recent years biologists have been measuring animals and have made definite progress in developing a yardstick for their evaluation. Most of the Tejon calves were measured soon after they arrived in Imperial Valley, and most of one group were measured just before they were ready for market. Unfortunately the age of these animals had to be estimated, and because these cattle were born and raised on a large range some difficulty was encountered in taking measurements.

These data are presented in table 17 and show that the Brahman and Brafords were 7 to 12 centimeters higher than the Herefords or Shorthorn-Hereford crosses as calves, even though the Brahmans were somewhat lighter. The same difference was also noted in the animals when marketed.

Other differences were not so pronounced except for the width and length of head, which was narrower and longer in the Brahmans and Brafords than in the Hereford and Shorthorn-Hereford crosses. In judging this difference by eye there appeared to be more of a variation than was actually found by measurements.

Slaughter and Carcass Data Show Similarity

As was mentioned earlier, differences in conformation between the animals appeared much greater to the eye than physical measurements revealed them to be (table 17). Height difference was most prominent. Similarly, when the monetary value of each carcass was calculated, it was found that carcasses from Brahmans, Brafords, Herefords and Shorthorn-Hereford crossbreds were more alike than expected. Herefords and Shorthorn-Hereford crossbreds graded higher than Brafords, which in turn graded higher than Brahmans.

Under feed-lot confinement the Brahmans were noticeably nervous and made smaller daily weight gains. They went to market at a lighter weight and carried less fat covering than the other animals. This had much to do with their grading lower. In addition, the conformation of the Brahman carcasses appeared less desirable to the grader. The Braford carcasses in these respects were superior to the Brahmans, but were not as attractive to the grader as the Hereford and Shorthorn-Hereford crossbred carcasses.

Brahman steers yielded as well as Hereford steers which were carrying more finish. Braford steers, equal in finish to Herefords and Shorthorn-Here-

Table 17. Average Weight and Body Measurements of Hereford, Brahman, Shorthorn x Hereford, and Brahman x Hereford Cattle*

Breed and sex	Estimated age in months	No. of animals	Av. wt.	Height at withers	Height at hooks	Heart girth	Length	Round	Loin	Head width	Head length
Brahman steers	7–8	7	452	111	116	136	114	83	....	18.1	39.5
Hereford steers	6–8	21	509	103	109	143	118	85	26.4	19.1	39.5
Braford steers	6–8	22	472	110	116	140	115	84	24.4	18.9	39.4
S × H steers	5½–6	6	430	101	107	140	115	83	26.5	19.3	38.3
Brahman heifers	7–8	5	411	109	117	134	113	82	....	17.9	38.7
Hereford heifers	6–8	24	484	101	108	142	116	83	25.9	18.9	38.8
Braford heifers	6–8	23	462	108	116	140	115	85	24.6	18.1	39.1
S × H heifers	5½–6	8	402	98	104	133	114	81	23.5	18.6	37.6
Brahman steers	15–16	7	816	126	131	172	137	91	29.6	20.3	47.1
Hereford steers	14–16	6	947	115	118	181	145	99	29.9	21.9	44.9
Braford steers	14–16	6	979	128	132	187	143	105	31.8	21.6	47.1
Brahman heifers	15–16	5	697	120	127	163	129	93	29.5	20.1	45.2
Hereford heifers	14–16	6	924	113	116	182	141	99	31.3	21.4	43.7
Braford heifers	14–16	4	805	122	125	175	136	103	31.5	20.3	45.6

* Weights are in pounds, measurements in centimeters.

ford crossbreds, yielded about 2 per cent more. This is in agreement with the work of Black, et al., (8). The differences in yield offset the differences in grade to the extent that live-weight values of all animals agreed more than was expected. Higher yield is attractive to the slaughterer and should rightfully be reflected in the returns to the producers of such animals. The Brahmans had the highest per cent of bone in the carcass and the least fat. This was expected, since these animals went to slaughter at a lighter weight carrying the least finish.

Some management practices that can be recommended in the area

Cattle Need Effective Shades

An unshaded cow standing in an air temperature of 100° F. has to dispose of a great deal of heat over a 10-hour period—about as much as is necessary to bring nine gallons of ice water to the boiling point.

Animal bodies collect heat through radiation from the ground and surrounding objects.* Shades 10 to 12 feet high, covered with an insulating material such as hay or a reflecting material such as aluminum sheeting, will materially decrease the radiant-heat load on the animal. (6) (7)

The difference in heat load on an animal under the best shade (air temperature at 100°) and an unshaded animal is 1,344 BTU per hour. To dispose of this extra heat the animal must evaporate 1.3 pounds of water per hour from its lungs by increased respiration—1.4 gallons over a 10-hour period.

Figure 8 shows several different shades, all covered by either hay or aluminum sheeting. In Imperial Valley the need to shade livestock is generally recognized. The advantage of shade for such valleys as the Sacramento and San Joaquin should be apparent from these experiments.

Shade height is important. Cattle prefer shades 10 to 12 feet high over those only seven feet high. Higher shades permit the animal to radiate excess heat to the relatively cool sky. But if the shade is too high the fast-moving shadow forces the animals to move frequently to hot ground, where they take on additional heat.

North-south orientation of shades is most common, primarily to keep total radiation of ground under shade ade-

* The investigation of shades was a cooperative project with the United States Department of Agriculture. See References 9 and 10.

Fig. 8. Artificial shade can be provided by hay- or metal-covered sheds at least 10 feet high. The one shown on the right is covered with aluminum sheeting.

Table 18. Heat Increments, Food Intake, Net Energy and Gain in Weight For Steers in a Hot Climate

No. of animals, dates, av. wt., daily gains	Ration per head (lb.)	Dry matter eaten (lb.)*	T.D.N. eaten (lb.)*	Metabolizable energy eaten (lb.)†	Heat increment of ration (million cal.)‡	Net energy intake/day (million cal.)	Net energy for maintenance (million cal.)	Net energy available for production (million cal.)
Hereford steers 4 Aug. 8–Sept. 5, 1950 Av. wt. 910 lb.§ Daily gain 0.86 lb.	Roughage 23.64 Concentrates 0	21.4	12.10	19.4	11.3	8.1	6.4	1.7
Hereford steers 8 Aug. 7–Sept. 3, 1951 Av. wt. 1,046 lb.§ Daily gain 1.73 lb.	Roughage 12.25 Concentrates 9.70	19.9	13.6	23.1	10.5	12.6	7.1	5.5
Hereford steers 10 July 2–Sept. 11, 1952 Av. wt. 795 lb. § Daily gain 0.78 lb.	Roughage 19.36 Concentrates 0	17.4	10.1	16.2	9.2	6.0	5.8	1.2
Hereford steers 12 July 2–Sept. 10, 1952 Av. wt. 804 lb.§ Daily gain 2.42 lb.	Roughage 13.97 Concentrates 8.60	20.4	13.6	22.9	10.8	12.1	5.8	6.3

* Morrison's Feeds and Feeding (Total digestible nutrients = T.D.N.)
† Armsby "Nutrition of Farm Animals" P. 675: 1 lb. T.D.N. in conc. = 1.77 million cal., 1 lb. T.D.N. in roughage = 1.6 million cal. metabolizable energy. For simplicity T.D.N. taken as equal to digestible organic substance with low fat content difference is negligible.
‡ Heat increment = 0.53 million cal. per lb. total dry matter eaten (Armsby's 3rd and 4th decimal are neglected as insignificant).
§ Metabolic body size = (weight in kg) $^{3/4}$ (Kleiber, "Hilgardia," 1932).

quate to dry feces and urine and to promote sanitation, although the heat load is slightly higher than for an east-west orientation.

Avoid a Roughage Diet in Hot Weather

Morrison* states that roughages have a much higher relative value for warming the body than for producing beef. This is usually stressed when cold weather maintenance rations are discussed, but it is also important to remember when feeding under high summer temperatures. A high roughage diet in summer will produce a large amount of heat that cannot be used for meat production, whereas a ration with some concentrate will produce about the same amount of digestible energy but less waste heat; consequently more meat is produced. This difference has been demonstrated on the Station several times in feeding trials. The following rough calculations further illustrate what takes place in the body on a roughage and a roughage concentrate diet (table 18).

Net Energy

The metabolizable energy of a feed represents the energy remaining after deducting the energy lost in the feces and urine. The heat increment is the heat produced in the body due to the increased metabolism brought about by consumption of food. This heat is only of value to the animal during cold weather. It is a detriment during hot weather. By subtracting the heat increment from metabolizable energy, net energy is obtained, which is the energy actually available to the animal for maintenance and production of body gain. It will be noted from the calculations that this figure is considerably lower for the roughage groups than for the concentrate lots. The concentrate lots seem able to take care of a little more total heat and still end up with more energy available for productive purposes.

* F. B. Morrison, *Feeds and Feeding*, 21st edition.

Finishing

It is probably not wise to put a high finish on cattle during the summer but to plan operations so they will be finished just before summer starts or after the hot weather. During the summer cattle show a drop in food consumption on any ration tested thus far, and, at least when hand-fed, it is sometimes difficult to get the concentrates very high and keep the animals on feed. Yet they do gain, as the table indicates. Feed-yards in the Valley report good gains during the summer even though there is a drop in food consumption and rate-of-gain during the hottest periods.

Even though a strictly roughage diet is not desirable for summer feeding, good quality alfalfa hay that has plenty of phosphorus has given excellent results during the cooler months. Several tests have shown this, but to cite one example:

Consuming an average of 17.72 pounds of good alfalfa hay per day, five Hereford steers started with an average weight of 391 pounds. Fed for 187 days in fairly cool weather, they gained an average of 1.99 pounds per day and weighed an average of 763 pounds at the end of the test.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of the following men and organizations whose cooperation made these experiments possible: Tejon Ranch Company, Bakersfield, Sterling Meat Company and Safeway Stores Inc., of Los Angeles. Members of the Agricultural Extension Service of Imperial County, Members of the Animal Husbandry Department at Davis, Harold Hunt, Keith Mets, Don C. Bassett, Fidel Gomez, Joe Bishop, and H. G. Farnsworth, farmers in Imperial Valley.

REFERENCES

(1) Regan, W. M. and G. A. Richardson
Reaction of the dairy cow to changes in environmental temperature.
Journal of Dairy Science 21:73–79. 1938

(2) Ragsdale, A. C., Samuel Brody, H. J. Thompson, and D. M. Worstell
Influence of temperature, 50° to 105° F. on milk production and feed consumption in dairy cattle.
Mo. Exp. Sta. Res. Bul. 425. 1948

(3) Kibler, H. H. and Samuel Brody
Environmental physiology with special reference to domestic animals.
Mo. Exp. Sta. Res. Bul. 464. 1950

(4) Bonsma, J. C., G. D. H. Scholtz, and F. G. J. Badenhorst
The influence of climate on cattle. Fertility and hardiness of certain breeds.
Farming in S. Africa 15, 7. 1940

(5) Seath, D. M. and G. D. Miller
High humidity not harmful to cows.
Dairy Res. Dig. (La. Sta.) 3 (3) 1945.

(6) Arrillaga, C. G., W. L. Henning, and R. C. Miller
The effect of environmental temperature and relative humidity on acclimation of cattle to the tropics.
Jour. of Anim. Sci. **11**: 50–59. 1952

(7) Kibler, H. H. and Samuel Brody
Influence of humidity on heat exchange and body temperature regulation in Jersey, Holstein, Brahman and Brown Swiss cattle.
Mo. Exp. Sta. Res. Bul. 522. 1953

(8) Black, W. H., A. T. Semple, and J. L. Lush. 1934
Beef production and quality as influenced by crossing Brahman with Hereford and Shorthorn cattle. U.S.D.A. Technical Bulletin No. 417

(9) Kelly, C. F., T. E. Bond, and N. R. Ittner
Thermal design of livestock shades.
Agr. Eng. **31**: 601–606. 1950

(10) Ittner, N. R. and C. F. Kelly
Livestock shades.
Jour. of Anim. Sci. **10**: 184–194. 1951

7½m-9,'54(4878)RMB

141